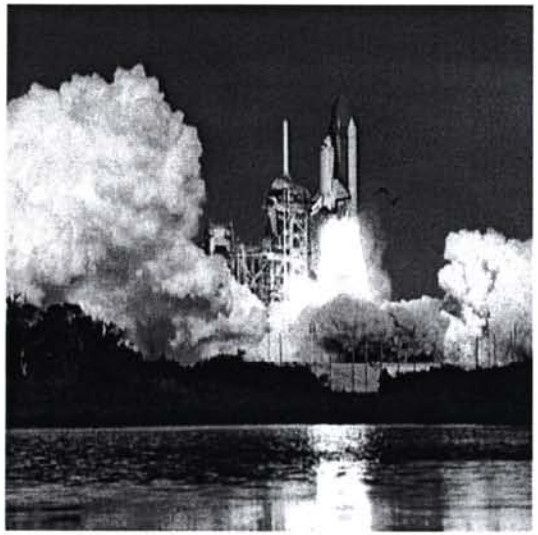
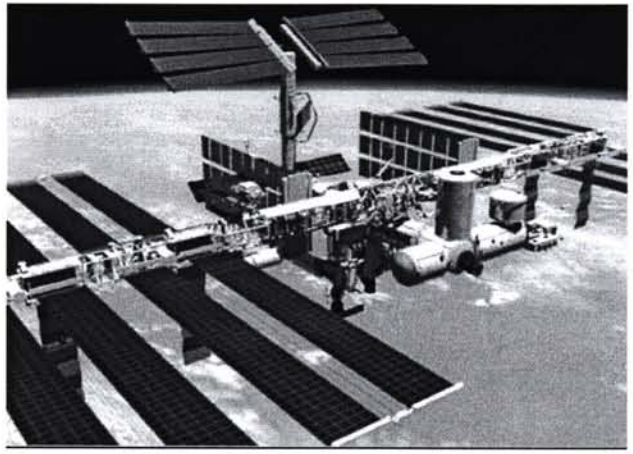
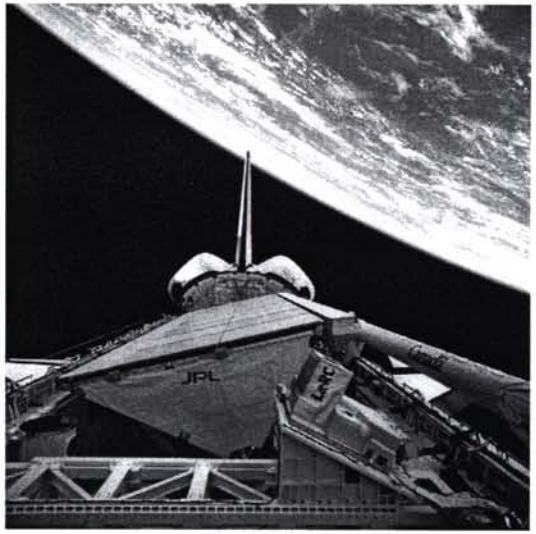
2002 Military & Aerospace/Avionics COTs Conference

Investigation of Low Glass Transition Temperature on COTS PEMs Reliability







M. Sandor/S.Agarwal
4800 Oak Grove Drive
Pasadena, CA 91109

Electronic Parts Engineering Office 514

JPL

Agenda

- Introduction
- Analytical Methods (Tg)
- Glass Transition Temperature (Tg)
- Coefficient of Thermal Expansion (CTE)
- Risks
- Tg Data
- Reliability Issues
- Reliability Investigations
- Summary

The work was performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration

JPL

Introduction

Many factors influence PEM component reliability. One of the factors that can affect PEM performance and reliability is the glass transition temperature (Tg) and the coefficient of thermal expansion (CTE) of the encapsulant or underfill. JPL/NASA is investigating how the Tg and CTE for PEMs affect device reliability under different temperature and aging conditions. Other issues with Tg are also being investigated. Some preliminary data will be presented on glass transition temperature test results conducted at JPL.

Tg Analytical Methods Available

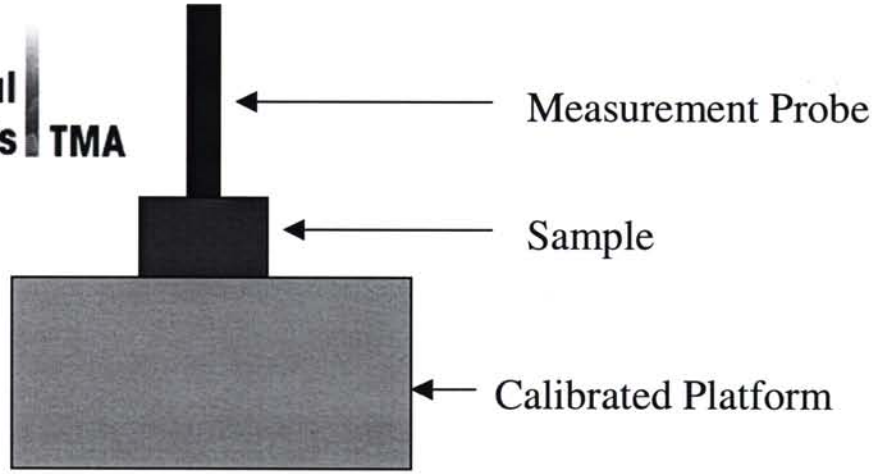
	Typical Time	Sample prep	Repeatability	Dependability	Comments
Differential Scanning Calorimetry	20 minutes	Easy	Good	Marginal	Many materials do not exhibit clear transitions
Thermo Mechanical Analysis	40 minutes	Medium	Fair	Good	Very dependant on sample preparation
Dynamic Mechanical Analysis	120 minutes	Difficult	Excellent	Excellent	Tg can be defined several different ways

Thermal Mechanical Analysis

TMA/SDTA840

Accessories

Thermomechanical Analysis TMA



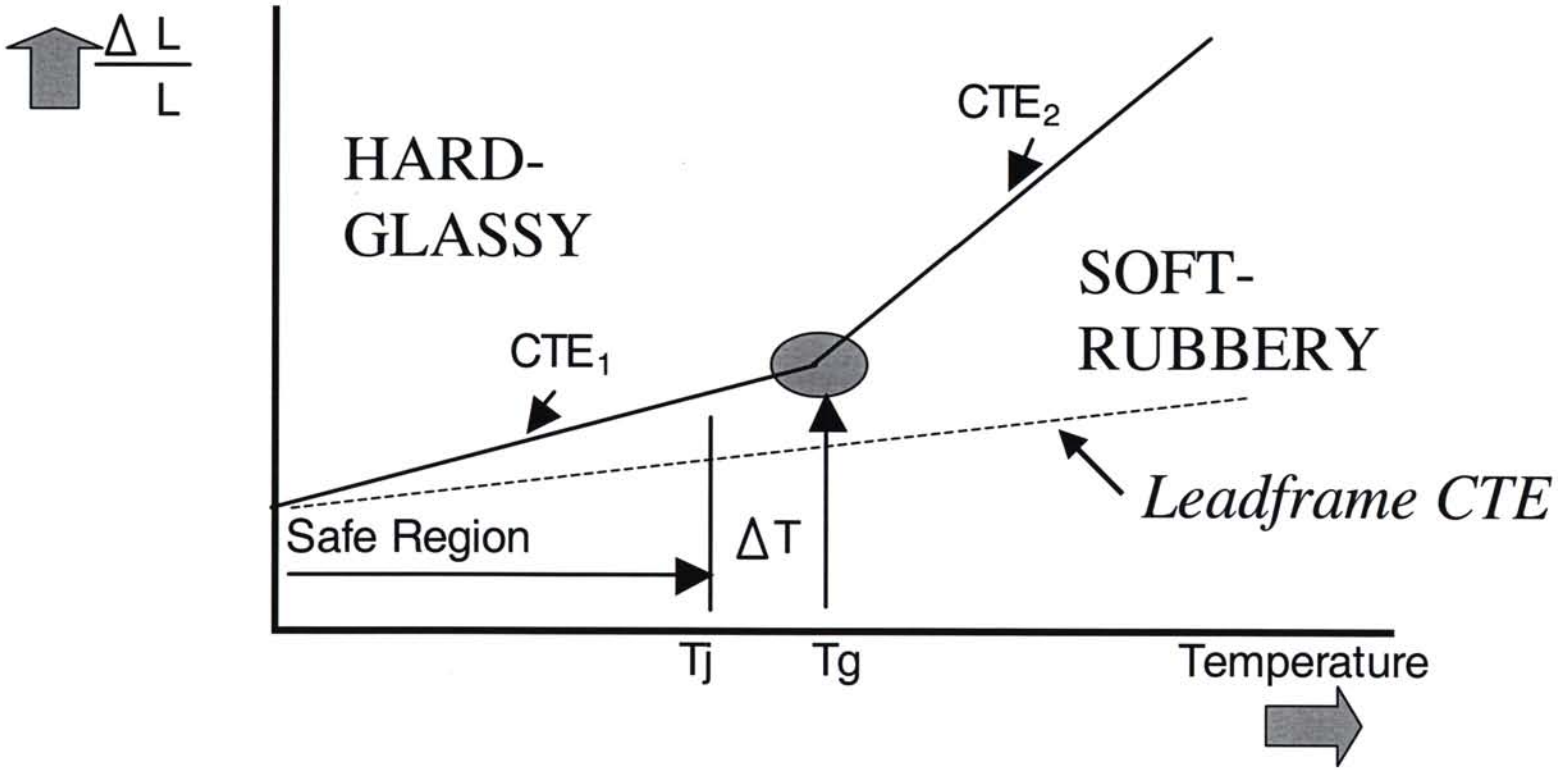
The method consists of heating the sample upon a expansion-calibrated platform and measuring the dimensional change of the sample with an instrumented probe. Probe placement can alter reading.

- ISO 11359-1:1999
  Plastics -- Thermomechanical analysis (TMA) -- Part 1: General principles

- ISO 11359-2:1999
  Plastics -- Thermomechanical analysis (TMA) -- Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature

Glass Transition Temperature (Tg)

PEM Tg is calculated as the midpoint of the temperature range at which a dramatic change in CTE occurs.



Coefficient of Thermal Expansion (CTE)

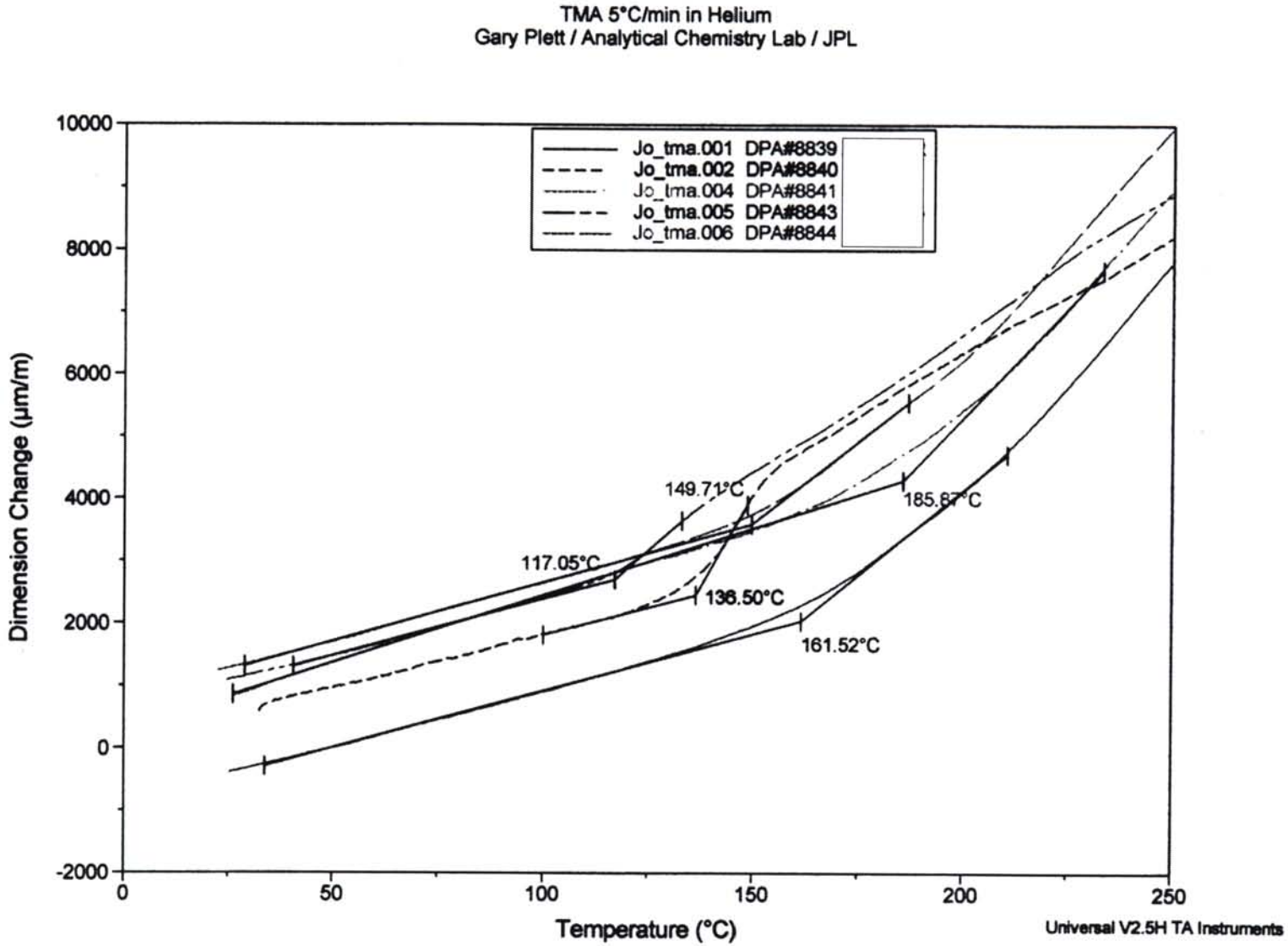
CTE is a measure of the fractional change in dimension (usually thickness) per degree rise in temperature. For microelectronics encapsulants, it is often quoted in "ppm/°C" (value x 10-6/°C). CTE is highly dependent on the chemistry composition, filler loading, and cure cycles of the encapsulant. It is desirable to have both a high Tg and a low CTE.

JPL

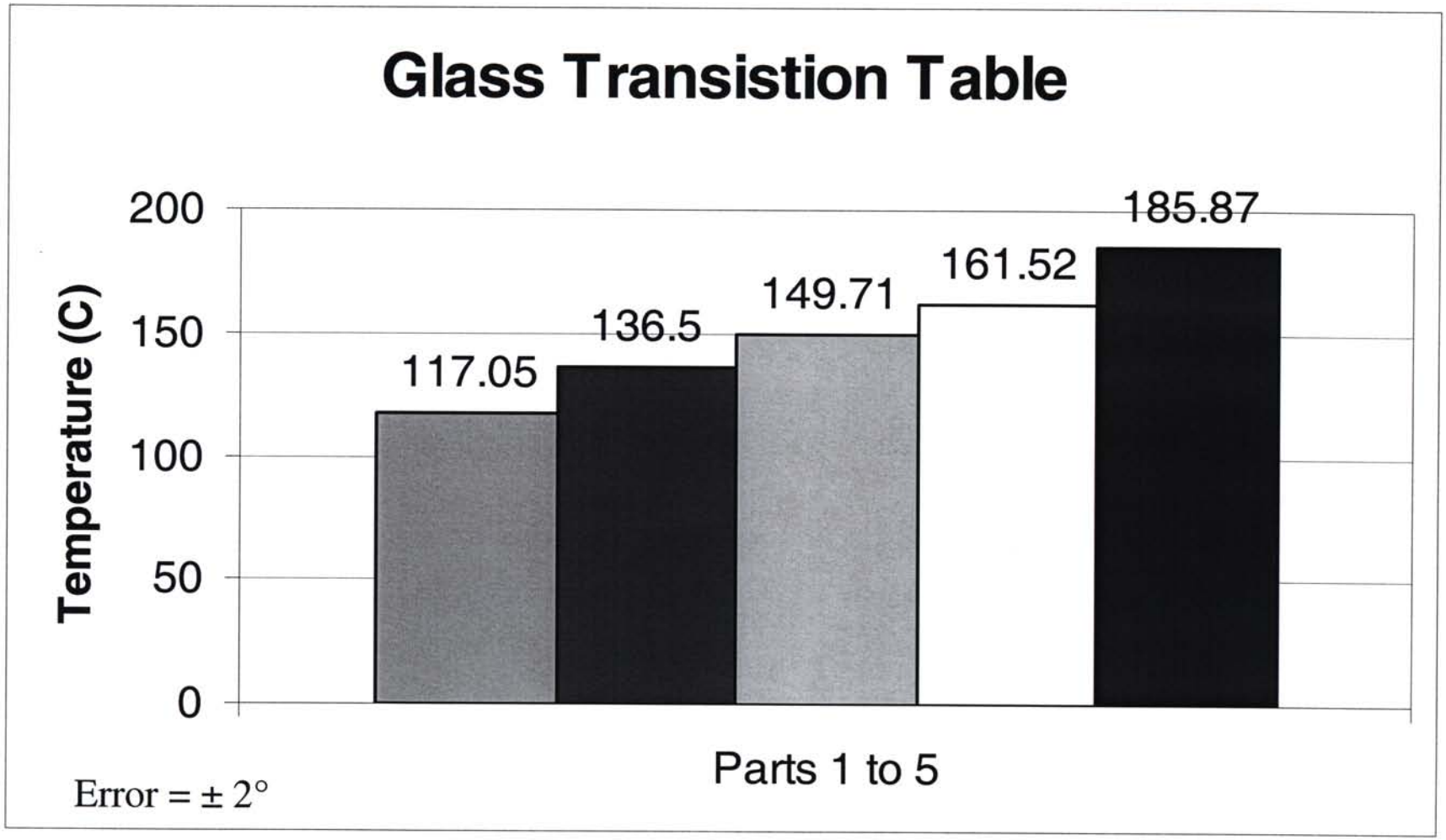
Risks When the Glass Transition Temperature (Tg) is Exceeded

- CTE of epoxy encapsulant will permanently change (breakdown of chemical cross-linking of polymers)
- Displacement of wire bonds resulting in a premature wear-out and breakage of wires
- Premature aging (e.g. storage)
- Induced stresses between materials internal/external) because of CTE mismatch; reduces temp. cycling capability
- Adhesion degradation
- Release of Bromine (flame retardant); can cause corrosion, lifted bonds due to release of ionics)
- Device performance degradation

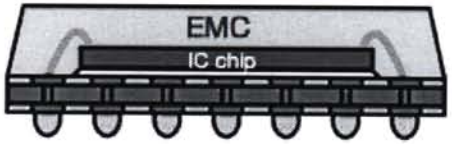
Tg Test Results for PEMs



PEMs Tg Test Results



Example of Semiconductor Vendor's Epoxy Molding Compound Properties Specified



General Properties					
Item	Unit	Condition	Newly Developed		Conventional
			CEL-300*	CEL-310*	CEL9200*
Spiral Flow	cm	IMMI-1-66	100	90	90
Gelation Time	sec	175°C	40	30	28
Tg	°C	TMA	120	110	120
CTE(a1)	ppm/°C	TMA	7	8	8
Flexural Modulus	GPa	JIS-K-6911	28.0	26.0	26.0
Water Absorption	wt%	PCT 20h	0.28	0.31	0.30
Flammability	-	UL-94	V-O	V-O	V-O

JPL

PEMs Issues for Further Investigation Relative to Tg

- Maximum allowable burn-in temperatures vs Tg (now under investigation)
- Derating required vs Tg (future)
- Reliability vs low and high Tg (future)
- Review of ASTM E595-93 methodology (future) (performing outgassing) when Tg <125°C

Maximum allowable burn-in temperatures vs Tg Investigations

Objective: Determine if devices fail or degrade when the BI temperature is at or above the part Tg as measured. What failure mechanism and modes can be expected?

- #1) Device Type A, Tg = 117C (30 parts split into three groups)

  Pre & Post Performance testing over temperature with +85C/+115C/+145C Burn-In for 240 hours

- #2) Device Type B, Tg = 136C (30 parts split into three groups)

  Pre & Post Performance testing over temperature with +85C/+130C/+150C Burn-In for 240 hours

Summary

- Changes in vendor's material properties, for PEMS, is occurring.
- Lower glass transitions temperatures observed and specified has raised concerns of PEM reliability for some Space applications and qualification.
- Applications demanding higher temperature environments and high temperature burn-in aging conditioning may compromise device reliability because of low Tg.
- From the studies and investigations of Tg vs reliability, JPL/NASA will develop criteria for the selection of suitable PEMs for Space applications.